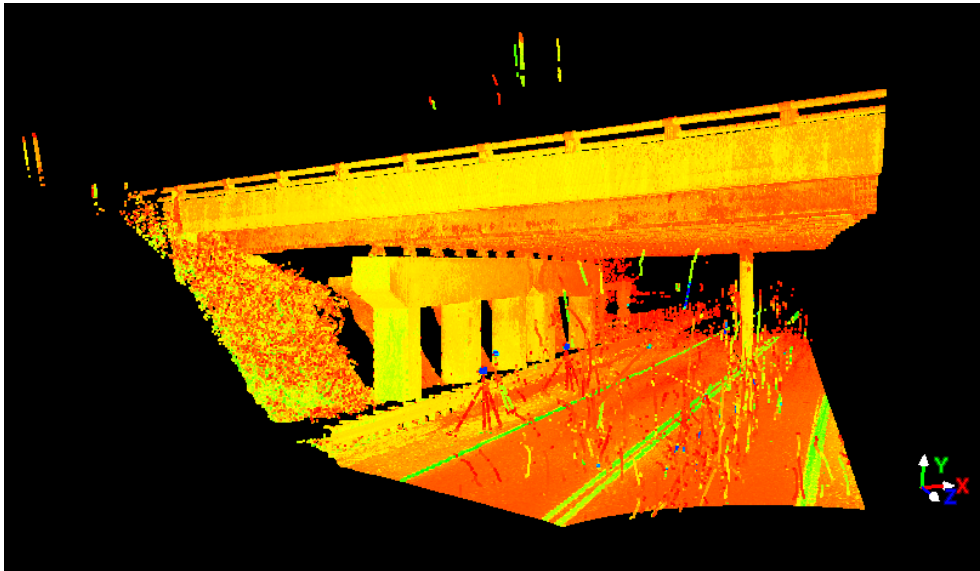


3D Modeling & 3D Laser Scanning for Bridge Inspection and Structural Analysis



Yelda Turkan, Ph.D.
Simon Laflamme, Ph.D., PE
Iowa State University

Current Bridge Inspection Methodology



Current Approach:

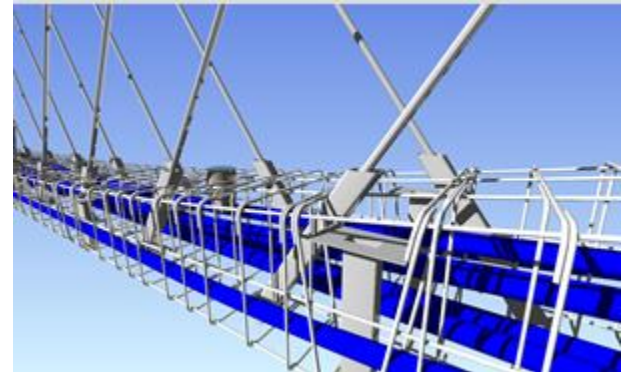
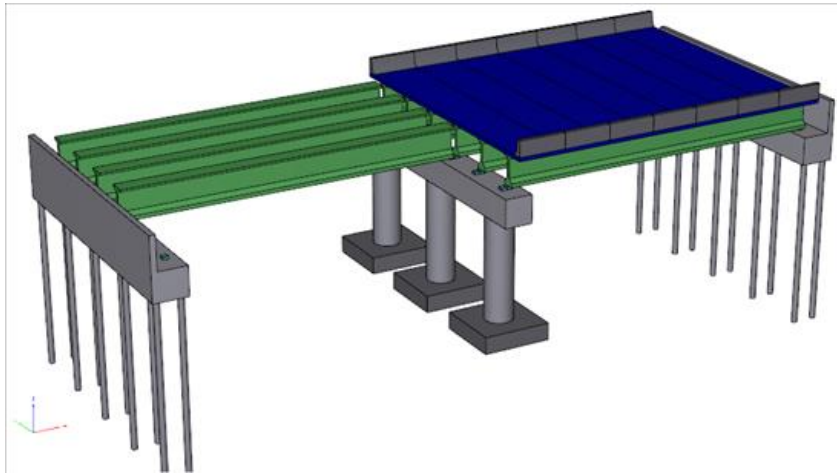
- Visual inspection
- Conventional surveying methods

Limitations:

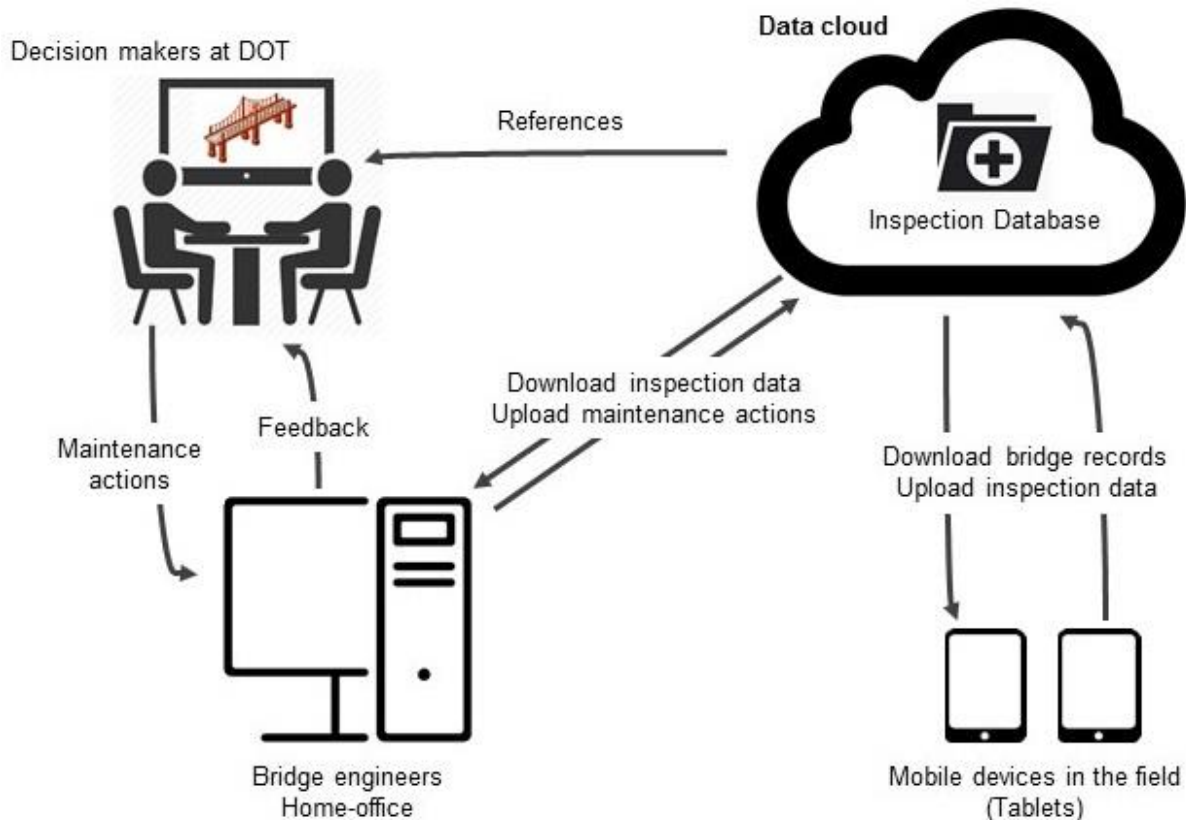
- Subjective and tedious data collection
- Cannot capture detailed geometries
- Requires extensive engineering resources to manually review and classify visual changes of structures
- Difficult to assess how local deformations and visual changes interact to drive global decaying patterns of bridges and structures

3D Modeling

- SmartMarket Report (2012)
- FHWA Initiative
 - BIM
 - CIM
 - Heavy Civil
 - BrIM
 - 3D Engineered Models



BrIM Enabled Inspection



Data Collection



Bridges 8550.2.R.030 and 8550.2.L.03

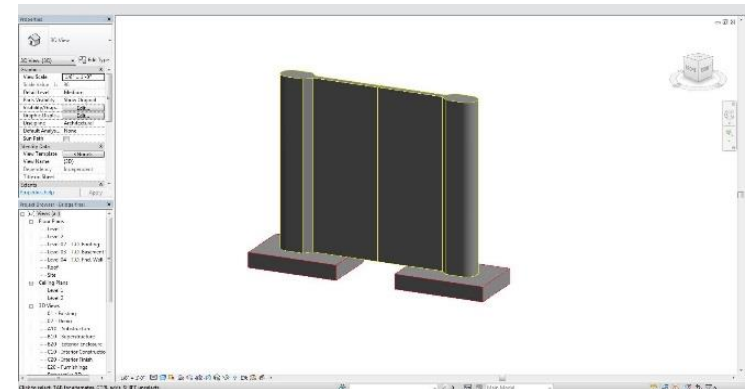
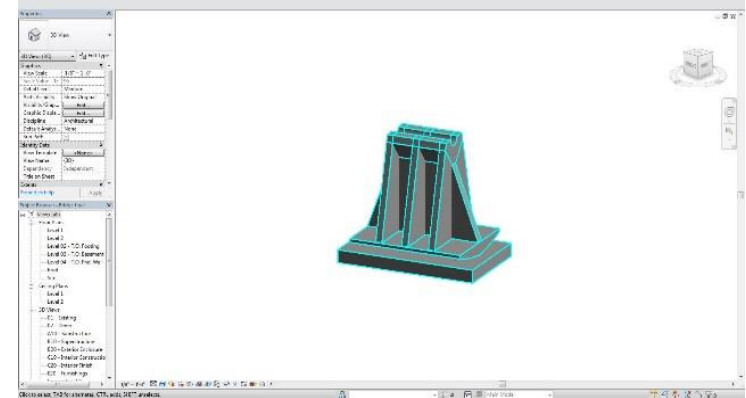
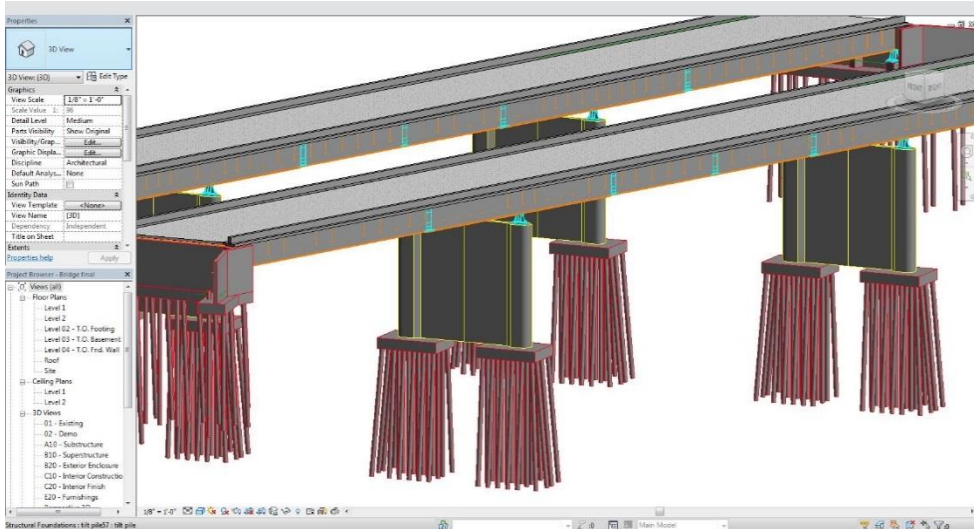


Bridges 8548.4.R.030 and 8548.4.L.030

- Iowa DOT Office of Bridges and Structures
 - Element Condition Data
 - 2D Drawings (pdf files)
 - Specifications

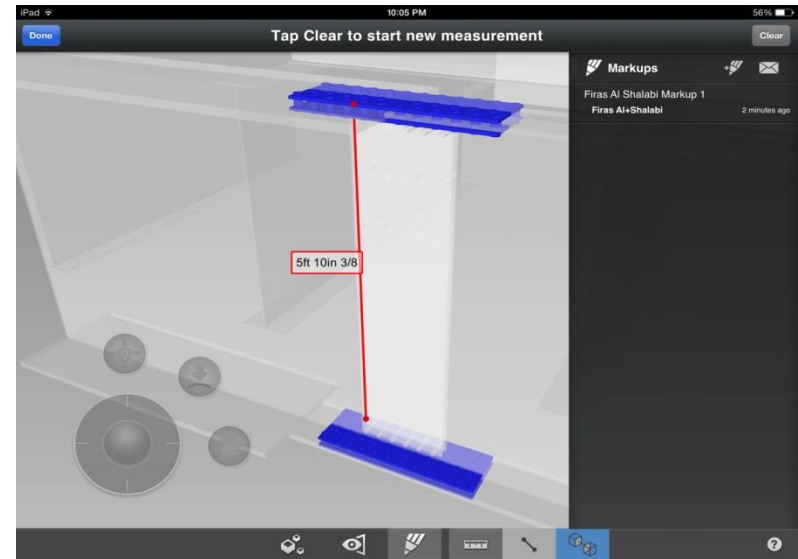
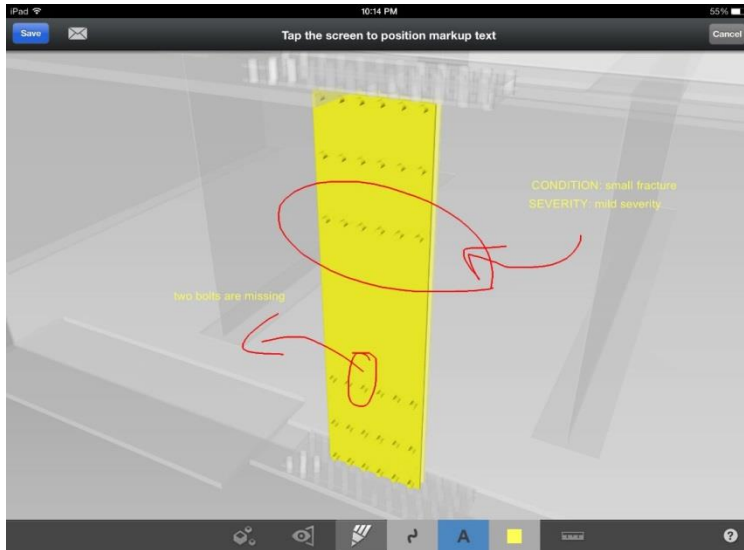
Scale	Bridge No.	8550.2.R.030	Sketch by	Date	Page
Sketch of: Legends			Team #1	10-7-04	10-7-04
NOTE: Cracks Are Hairline Unless Otherwise Noted					
	-Scale	L-light M-moderate S-severe		-Hollow	
	-Spall			-P.C. Patch	
	-A.C. Patch			-Injected Epoxy	
	-Leaching			-Staining	
	-Pattern Cracking			-Map Cracking	
	-Random Cracking			-Stalactites	
	-Exposed Reinforcing			-Bearing location	

3D Modeling



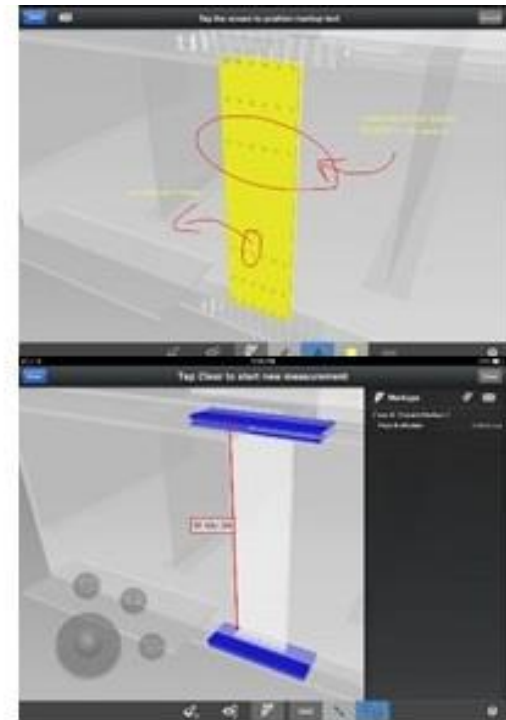
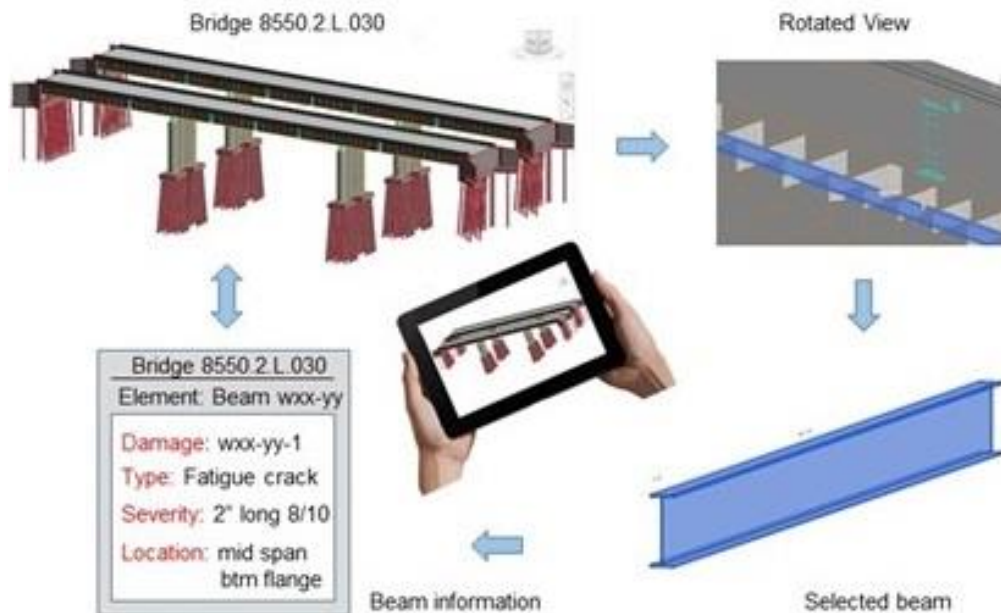
- Autodesk Revit
- Modeling with the same level of detail:
 - deck, super structure, sub-structure, channel and piers

Revit to BIM 360 Glue



- Cloud storage
- Access and modify 3D BrIM in the field

BrIM Enabled Inspection Process



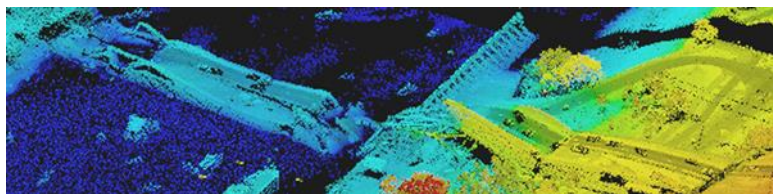
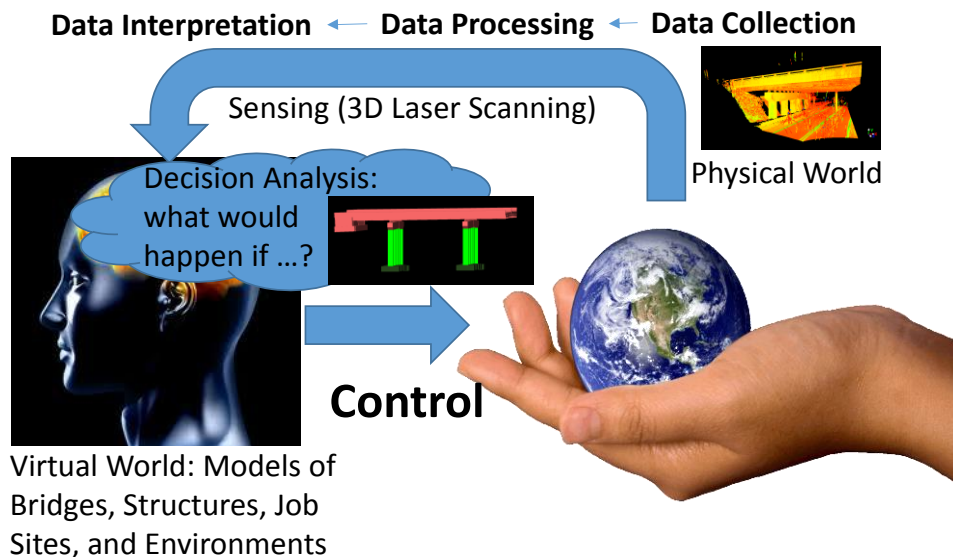
BrIM On-site Demonstration



- Qualtrics Survey
 - Eight state DOTs; bridge engineer to director of bureau of structures

Task	Results	Remarks
Inspection Means	71% paper based 14% PDA 14% others	
Number of Inspectors	15 – 75	The number can reach up to 650 with all qualified consultants
No. of inspectors in each inspection	2 – 4	Can reach to 7 for major over water bridges
BrIM usage in design & construction	33% using it	
Challenges in the current practice	60% have challenges	<ul style="list-style-type: none"> • Close observation and management to stay on compliance • Training inspectors • Inadequate staff • Aging staff • New problems with new bridge designs.
Future use of BrIM in inspection	71% denied any future plans	
BrIM staff knowledge	62% poor – fair 13% good 25% V.Good - Exc	
Usefulness of BrIM for inspection	71% neutral	29% sees it as useful

3D Imaging for Infrastructure Projects



3D LiDAR data of I-35 Bridge in 2007

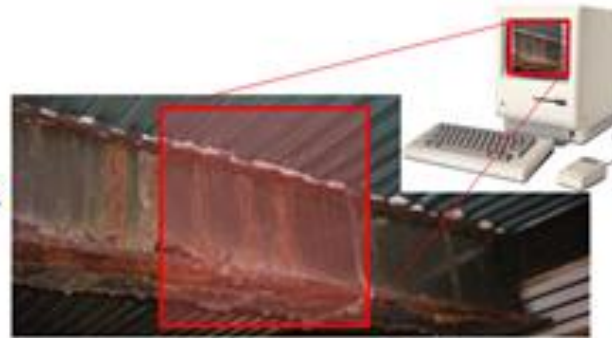
<http://www.aerometric.com/projects/i-35w-bridge-collapse>

- Importance of detailed geometric analysis of bridges and structures
- Cost, safety, and mobility implications of detailed geometric analysis of structures
- Limitations of current methods
- 3D laser scanning and automatic data processing for reliable and detailed bridge inspection and structural analysis
- Potential value of laser scanning in bridge and infrastructure programs and projects
- Risks, barriers and further development

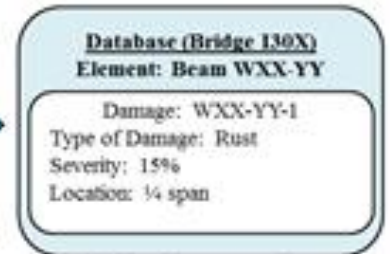
Research Vision



(a) automatic scanning



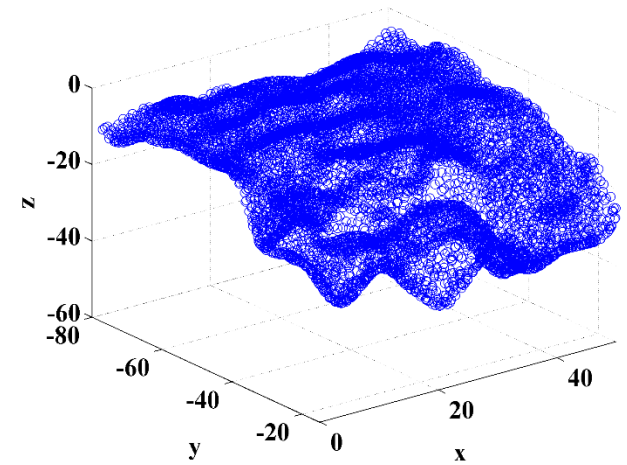
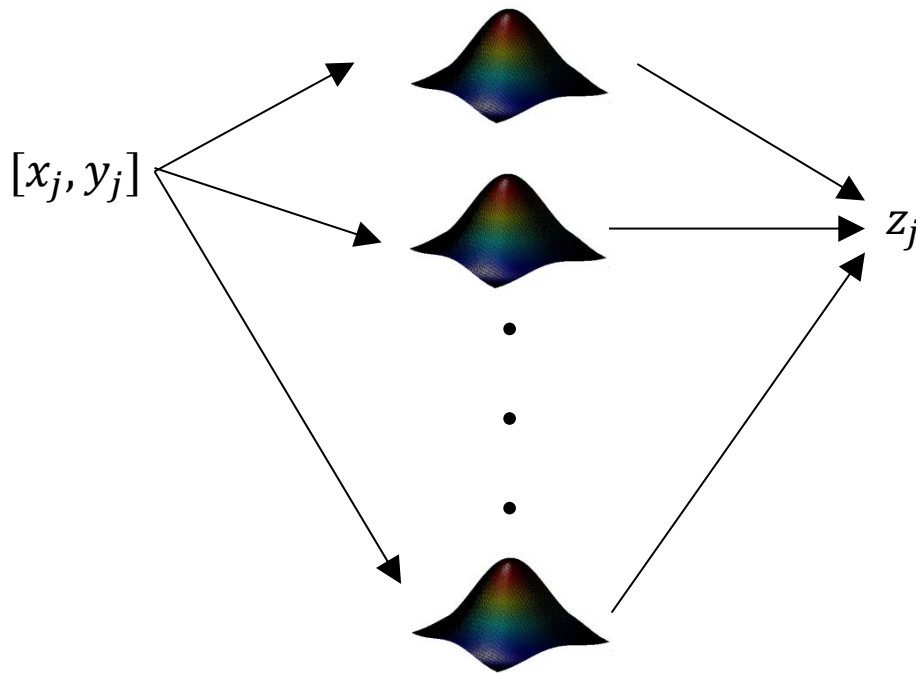
(b) computer vision



(c) database update

Wavelet Network

Compact Representation

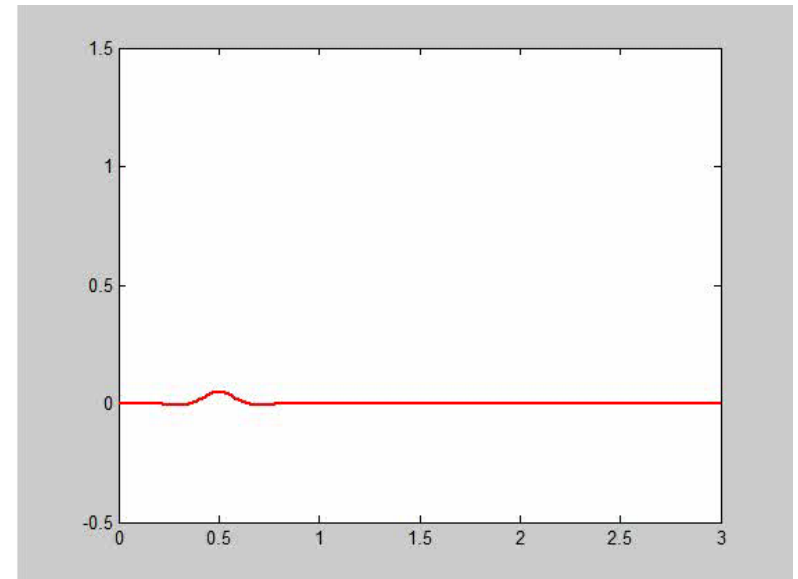
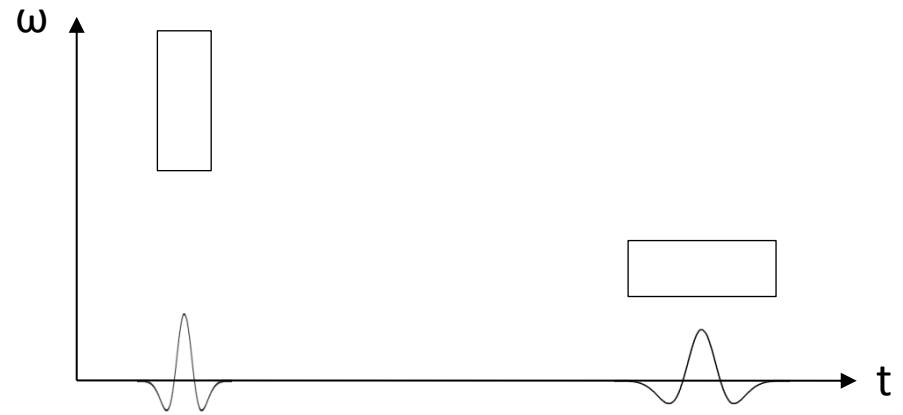
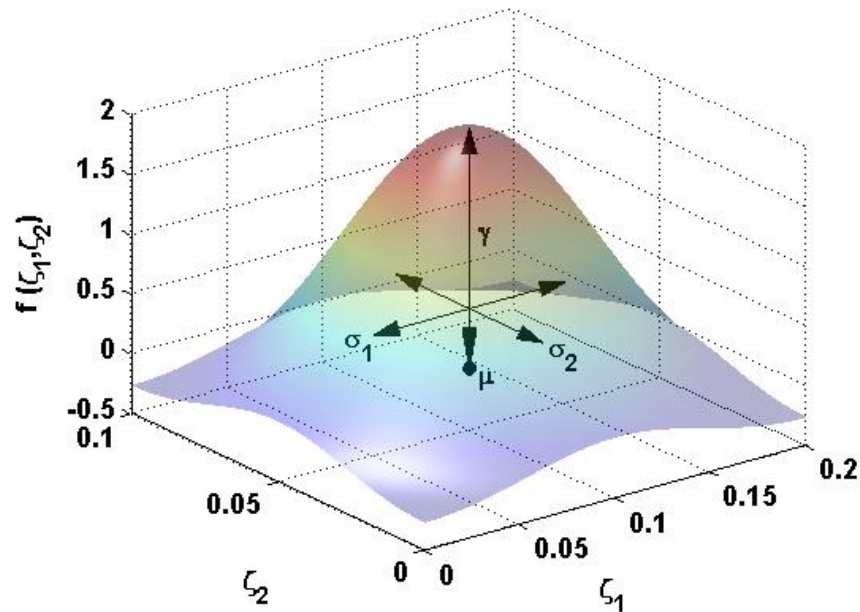


$$z_j = \sum_{i=1}^h \gamma_i \phi_i(x_j, y_j)$$

➡ universal approximation capability

Wavelet Network

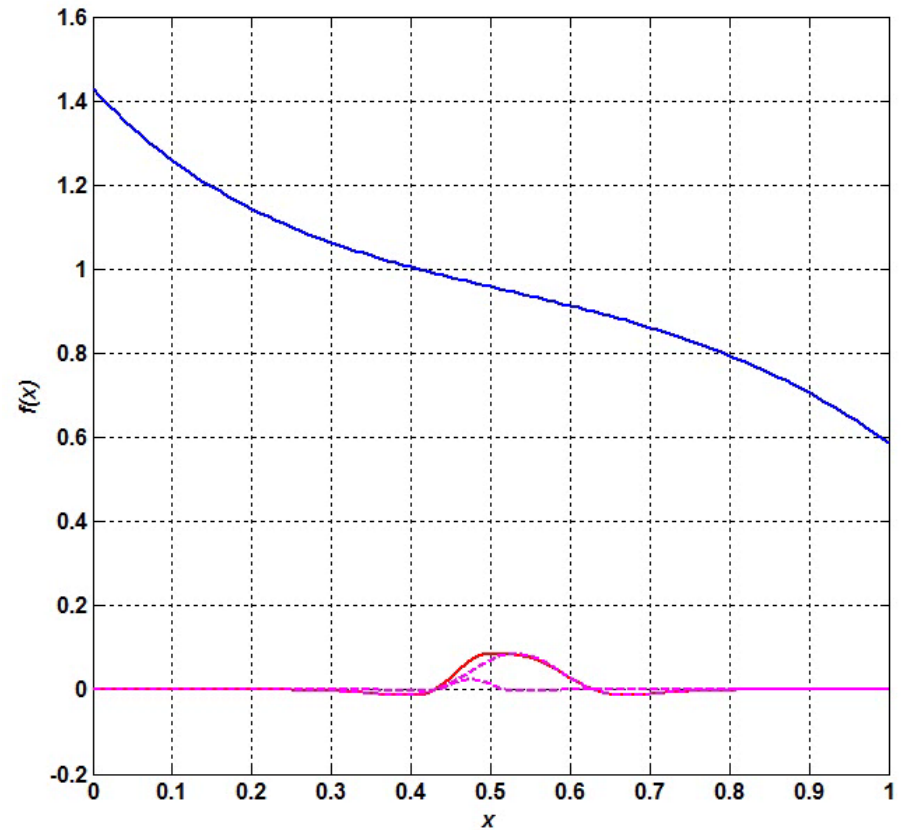
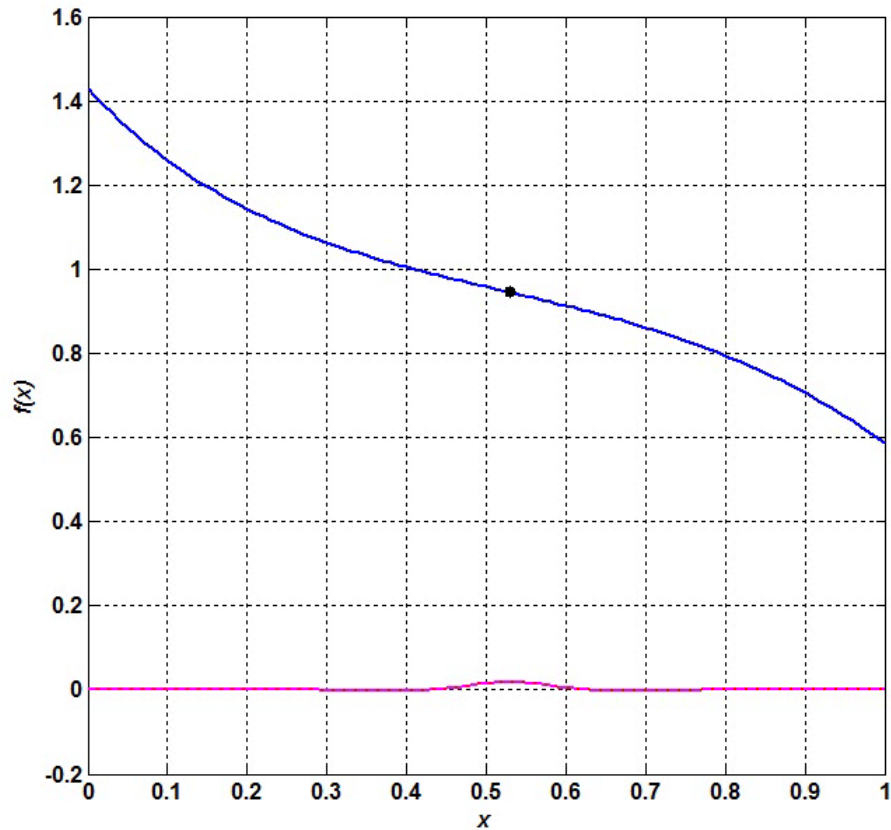
Principle



Laflamme, S., Slotine, J.-J., & Connor, J. J., "Self-Organizing Input Space for Control of Structures", *Smart Mater. Struct.* 21 (2012), 16pp.

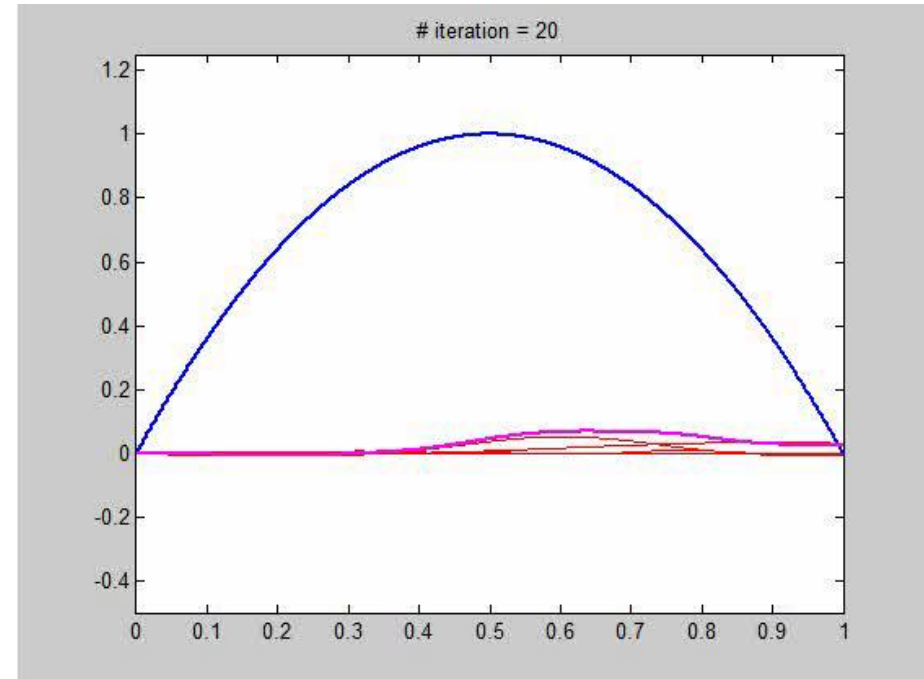
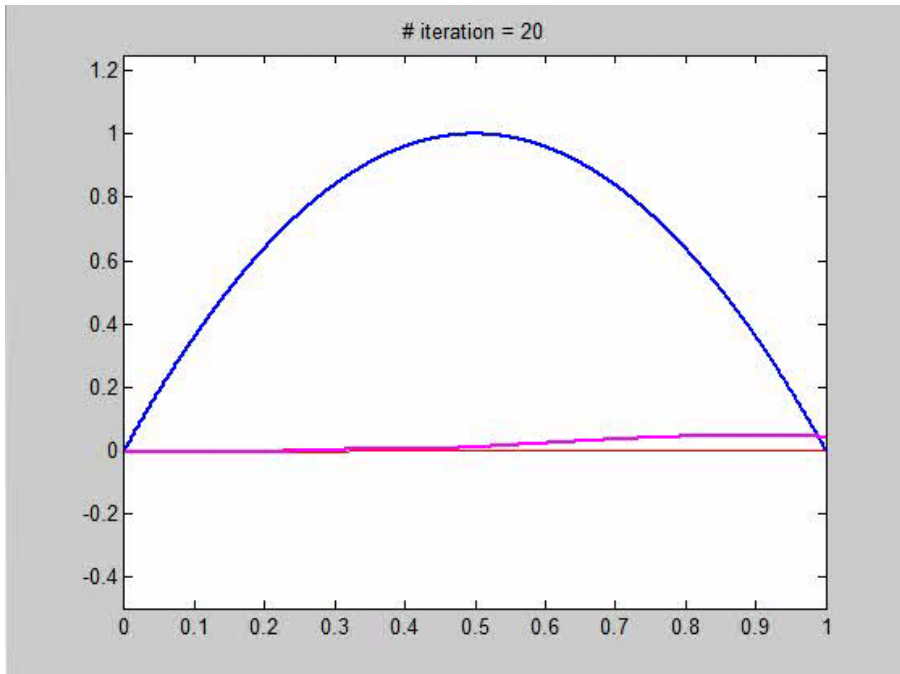
Wavelet Network

Sequential Identification



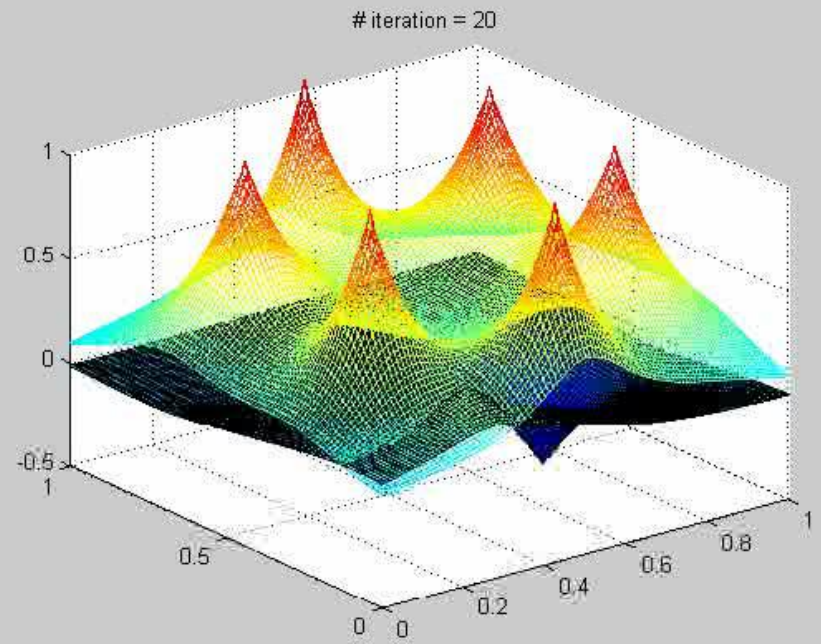
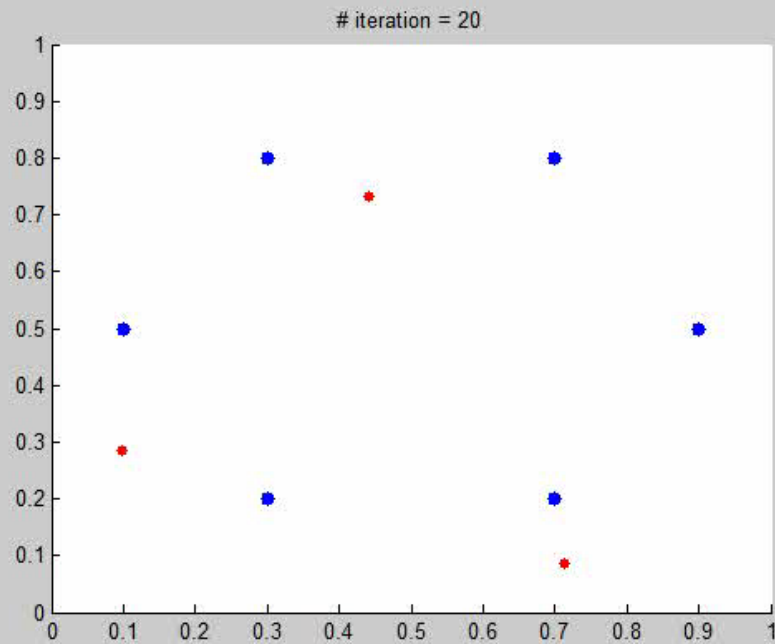
Wavelet Network

Network Resolution



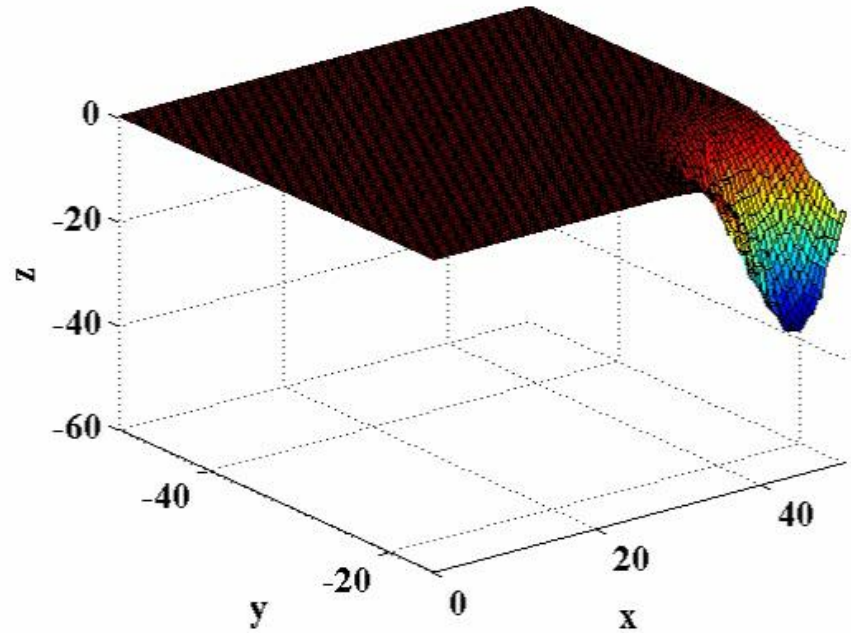
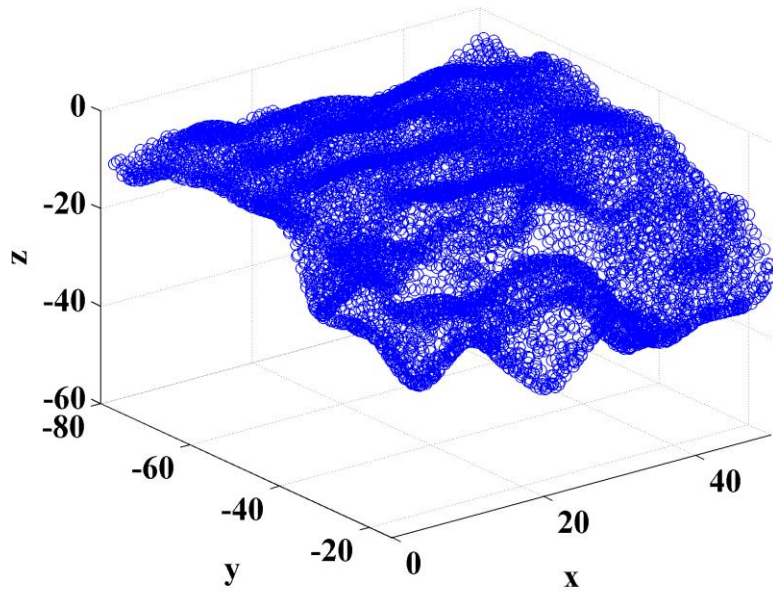
Wavelet Network

Example



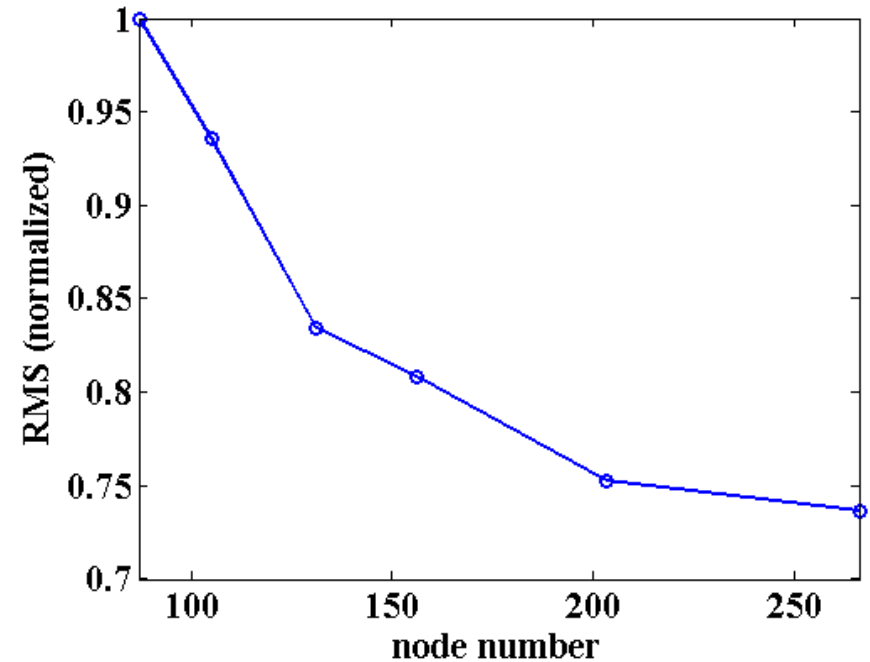
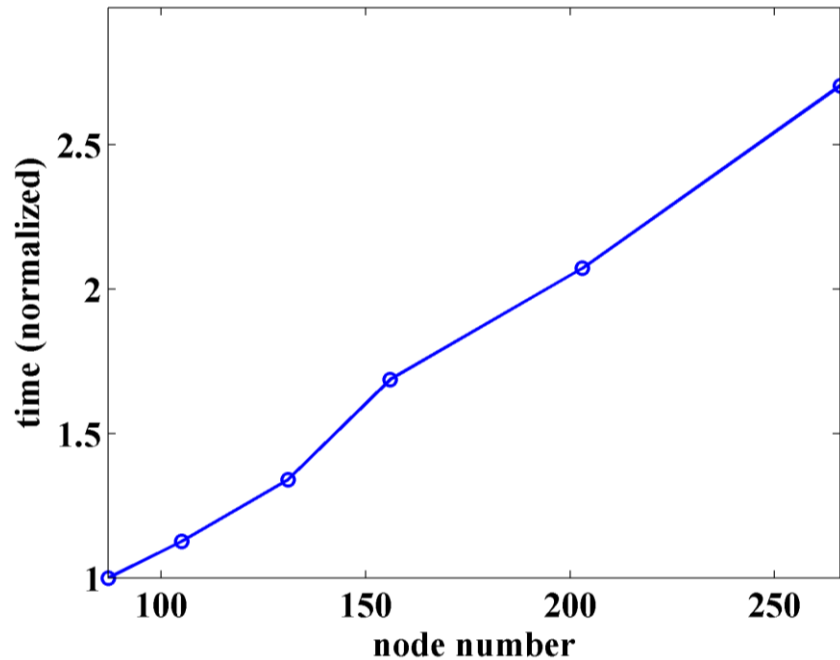
Wavelet Network

Application to point clouds



Wavelet Network

Application to point clouds



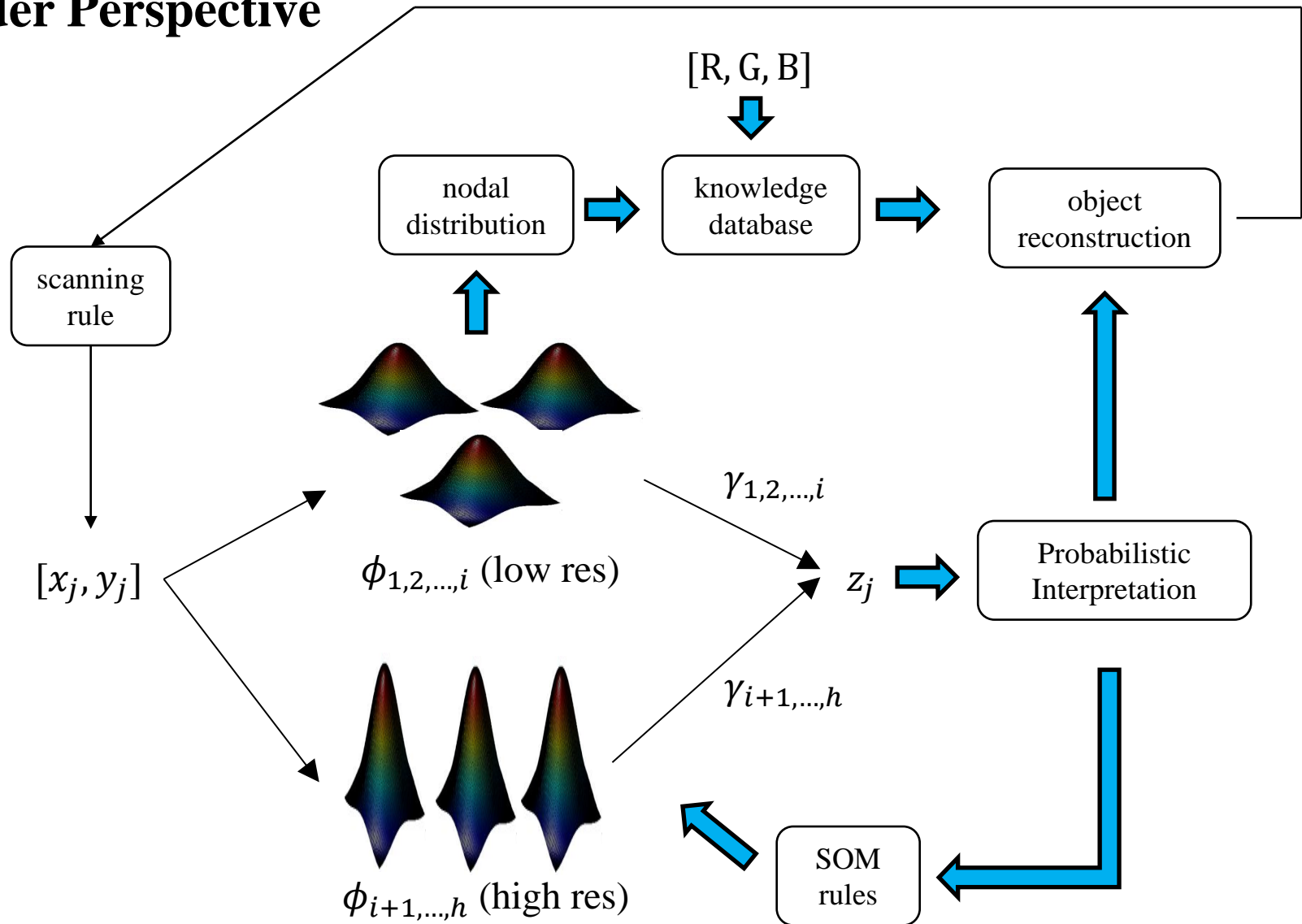
Integration with 3D Scanning

Challenges

- Need to learn on-the-spot
- Develop integrated learning and scanning strategies
- Establish network design procedures (resolution vs size)
- Recognize shapes and features

Integration with 3D Scanning

Broader Perspective



Thank you.. Are there any questions?



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